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ZURICH

Risktopics

snow loading roof collapse

Roof Collapse Due to Winter Storms

Winter storms, including rain, snow and ice account for several roof collapses each year. These collapses account for millions of dollars in property damage and interruption of production and operations. Are you prepared for the next winter storm? Is your building capable of handling the load from a heavy snow? This Risk Topic is intended to help plant management implement appropriate procedures and inspections to deal with the perils from a winter storm.

It is not just the blizzard that produces a single significant snow fall that causes a roof system to fail. Repeated snow events that do not have time to melt can accumulate and surpass the roof design's live load. Equally important is a snow event followed by rain. The rain will saturate the snow, which will greatly increase the weight of the snow.

Why Do Roof Collapses Occur?

A partial or complete roof collapse can occur for several reasons. Most of the causes are preventable if measures are taken beforehand to address roof design, snow removal and ensure that roof drains and gutters are clear and flowing freely. A few of the reasons that roof failures occur are:

1. Incorrect roof live load design. This can either be from allowing a reduction in the live load during the design phase, which is unfortunately allowed by some building codes. For example, some building codes allow for a 30% reduction in the live load. So a ground snow load of 30 psf may be reduced to 21 psf. The reason the reduction is allowed is based on the belief that the wind typically blows during a snow event and a reduced amount of snow will accumulate on the roof. Based on loss history, collapses have occurred when the actual snow load was above the reduced snow load, but below the design snow load.
2. Problems with the installation of the roof steel. Most bar joist roof frames are welded, while some of the primary steel beams have bolted flanges. If the welds are not done correctly or the bolts are not torque to specification, premature failure of the roof structure can occur.
3. Roof drains and/or downspouts become blocked or frozen and melting snow or rain can not adequately drain from the roof.
4. Over time, additional dead load (weight) is added to the roof, which will reduce the available live load or roof design. The increased dead load can come in the form of adding HVAC equipment, installing a new roof covering or hanging conveyors from the roof steel. A structural engineer should be consulted prior to adding any additional weight to the roof structure.
5. Imbalance of snow load on roof.

Before the Next Winter Storm

Here are some action items that you can take to reduce the chance of experiencing a roof collapse:

1. Know the live load design of all sections of your roof. This will let you know how much snow your roof can safely handle. Since lower roof elevations typically promote drifting snow, these areas are typically designed with greater roof strength. If your roof strength is not known, contact a structural engineer to determine the live load your roof can support. Structural reinforcing should be performed, especially on lower roofs, as needed.
2. Inspect and clean roof drains, gutters and downspouts each fall.
3. Solicit a local roofing contractor that will assist in snow removal. Have the roofing contractor on retainer, if possible.

Warning Signs Associated with Potential Roof Collapse

Prior to a roof collapse, buildings generally exhibit signs that the roof is in distress and action should be taken to mitigate a roof collapse. The following are some of the symptoms that have been reported prior to roof failure:

1. sagging roof steel – visually deformed
2. cracked or split wood members
3. sprinkler heads pushed down below ceiling tiles
4. doors that pop open
5. doors or windows that are difficult to open
6. bowed utility pipes or conduit attached at ceiling
7. creaking, cracking or popping sounds

Plumb bobs and other laser-type leveling tools can be used for tracking the following:

1. bowing of truss bottom chords or web members
2. bowing of rafters or purlins
3. bowing of headers or columns

Actions You Can Take To Prevent Roof Collapse or Snow Damage:

The majority of roof collapses can be prevented if appropriate action is taken prior to winter weather. It is recommended that a winter storm contingency plan be developed. The following items should be addressed before and during a snow or rain event:

1. Keep roof drains clear of ice and accumulated debris. Inspect roof immediately after major winter storms where precipitation more than 8 inches of snow fall and/or 2 inches of rain fall has occurred in a 24 hour period.
2. Keep gutters and downspouts clear so they will flow freely.
3. Provide heat-tracing in gutters and downspouts.
4. Keep the bottom of downspouts clear of snow and ice so the water has a place to drain.
5. Truncate downspouts 2 feet above grade to ensure they flow freely and do not freeze at the bottom.
6. Ensure that snow is not plowed or shoveled against downspouts, which will prevent proper drainage.
7. Remove snow accumulations from the roof when approximately 50% of design strength is reached.

Snow Load Based on Accumulation Depth[3]

Snow Depth on Roof (ft.)	Dry Snow (lbs./ft.^{2})	In Between Snow (lbs./ft.^{2})	Wet Snow (lbs./ft.^{2})
1	3	12	21
2	6.5	24	42
3	9.5	36	62
4	12.5	48	83
5	15.5	60	104

8. Do not install equipment (air handlers, air conditioners, transformers, etc.) or storage below eaves where the equipment could be impacted by snow or ice sliding off the roof.
9. If there is existing equipment located below eaves, a structurally sound roof should be installed over the equipment to help prevent damage to the equipment from falling snow or ice.

If You Suspect Your Roof Has a Problem

In the event that any of the collapse warning signs is present, immediate action can help prevent a roof collapse. The following should be performed:

1. Contact a structural engineer to evaluate the building.
2. Initiate snow removal if safe.
3. Initiate emergency actions, such as removing mobile equipment, covering equipment and storage with plastic, backing-up computer systems, etc.
4. Contact your local Zurich Risk Engineering consultant.

Snow Removal Preparation

The removal of snow accumulations on roofs, which will take the weight off the roof, is the best way to prevent a loss. It is important to consider how snow removal will be performed in advance of the snow season. The following items should be considered:

1. Evaluate if snow removal can be performed safely by plant personnel – maintain removal equipment on site (snow blower, shovels, wheelbarrow, etc.)
2. Evaluate if plant personnel can remove the snow in a timely manner.
3. Select a roofing contractor in advance and retain them on contract.
4. The use of salt on most roofs will void the manufacturer's warranty.

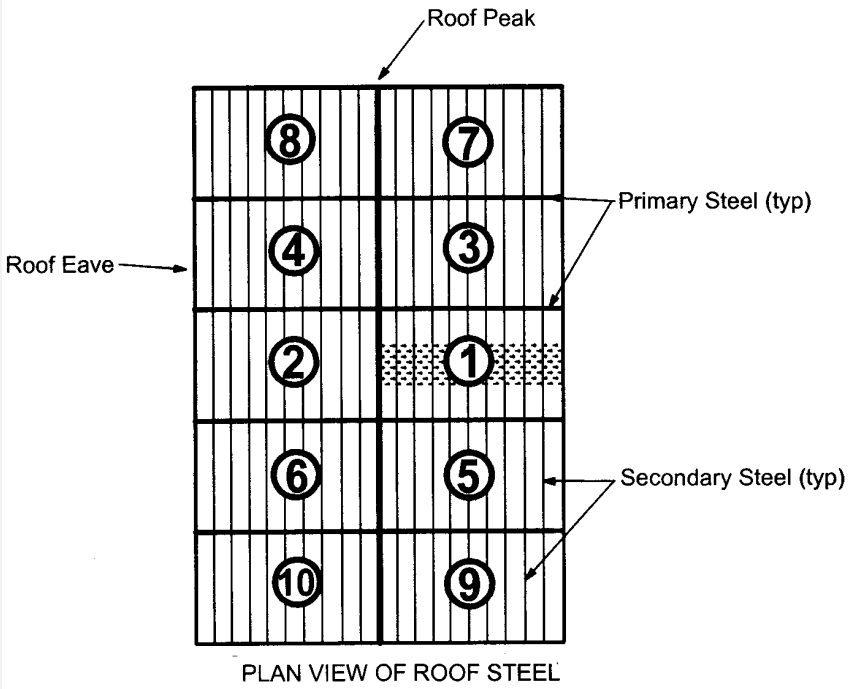
Snow Removal

It is important to follow proper snow-removal procedures. A plan should be developed based on your building's layout. Improper snow removal can create undesired loading on a roof. Follow these procedures to properly remove snow from your roof:

1. Drifted snow should be removed first, which will generally be on lower roofs. Drifted snow can also occur around rooftop mechanical vents, skylights, parapet walls and around penthouse walls.
2. Snow should be removed from the middle of the bays first. (i.e., if your building has 50 foot bays with the primary steel running from the peak to the eave, the snow should be removed from the center of the bay starting at the peak and working toward the eave.) The greatest deflection will occur at the center of the bay. This should be repeated for all the bays.
3. It is important to remove snow evenly from both sides of the roof so that the live load on one side of the roof is not significantly greater than the other side. For peaked roofs, the snow should be removed from the center of a given bay on one side of the roof and then the snow should be removed on the same bay on the other side of the ridge or peak.
4. Do not pile snow from upper roofs onto lower roofs.
5. Take care while removing snow and/or ice accumulation to prevent damage to the roof membrane. Avoid removal within 2 inches of the surface of the roof membrane. The use of plastic snow shovels is recommended.

6. When removing snow from one section of a roof, avoid travelling over and compacting snow on adjacent roof sections.

Snow Removal Procedure



PLAN VIEW OF ROOF STEEL

1 Remove snow from center of bay first. Start in between the primary steel and clear a path from the peak to the eave. Clear the entire bay from the center working towards the primary steel.

2 Repeat for bay on opposite side of the peak.

3 through 10 Repeat the process described in 1 and 2 above until the roof is clear.

REFERENCES

1. *Open Web Steel Joists – Roof and Floor Loading Guidelines.* Province of Nova Scotia. Crown, 2003.
2. *Snow Loading & Roof Failures Alert*. Ontario Recreation Facilities Association Inc. Facility Alert, 2002-03.
3. *Winter Snow Loads.* Curt Gooch, Sr. Cornell University. 2002
4. *Roof Snow Loads.* William J. Abngell. University of Minnesota Extension Service: Regents of the University of Minnesota, 2003.
5. *Snow Load on Buildings*. Michael J. O'Rourke. American Scientist, January – February 1997.
6. *National Oceanic and Atmospheric Administration.* National Weather Service: National Operational Hydrologic Remote Sensing Center (NOHRSC) Snow Model (NSM), 2003.

National Weather Service – NOHRSC Snow Model (NSM)

- **National Snow Water Equivalent** The latest national snow water equivalent map from the NOHRSC Snow Model (NSM) can be obtained from www.nws.noaa.gov.
- The data is updated every 12 hours.
- The snow water equivalent should be used to determine actual snow load based on accumulation depth.

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